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The AEROVOX Research Worker

The Aerovox Research Worker is edited and published by the Aerovox Corporation to bring to the Radio Experimenter and Engineer, authoritative, first hand information on capacitors and resistors for electrical and electronic application.

VOL. 19, NO. 11 NOVEMBER, 1949 Subscription By Application Only

The Citizens Radio Service

By the Engineering Department, Aerovox Corporation

ON June 1, 1949 the Federal Communications Commission inaugurated the Citizens Radio Service on a regular licensing basis. Prior to that time, stations operating in this band (460-470 Mc.) were governed by experimental rules, pending finalization of the regulations by the FCC. The new service provides, for the first time, means whereby a private citizen may engage in two-way radio communication without being required to pass a technical examination.

Because of the simplicity of the new licensing procedure, and the long-standing need for such a service, it is anticipated that the citizens band will become a very important aspect of ultra-high-frequency radio. This issue of the AEROVOX RESEARCH WORKER contains a general discussion of the rules controlling this service, the technical requirements of the equipment employed, the possible applications of citizens stations, the propagation characteristics of this portion of the UHF band, and the implications of this new service in the servicing and manufacturing fields.

Regulations

The detailed regulations governing the Citizens Radio Service may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for a fee of five cents. This reprint from the "Federal Register" of April 5, 1949 is designated "F. R. Doc. 49-2517." Application for Citizens Radio Service construction permit and station license may be made on FCC Form 505 to FCC Field Engineering Offices or to Washington, D. C.

FIG.1

In general, the rules provide for the operation of a citizens radio station by any citizen of the U. S. who is over eighteen years of age and who possesses citizens band equipment *which has been approved by the FCC.* The licensing procedure for those thus qualified is quite "streamlined," requiring merely the submission of the non-technical, single card application form (Form 505). The normal term of the license is five years from the date of issuance. It authorizes the holder to communicate with other Citizens Radio Service licensees on a frequency-sharing basis for pleasure, utility, or indirect profit. By "indirect profit" it is meant that the service may be used as minor instrumentation in a business. For instance, a doctor might use the citizens band for a private call system to maintain contact with his home or office. The service may *not* charge for messages, handle program material in any way connected with radio broadcasting, transmit directly to the public through public address systems, or for other purposes contrary to Federal, state or local law. The FCC regulations define the Citizens Radio Service as "a fixed and mobile service intended for use for private or personal radio communication, radio signalling, control of objects or devices by radio, and other purposes not specifically prohibited herein." The artists sketch of Fig. 1 illustrates the most popular concept of such "personal radio communication."

Due to the non-technical nature of the citizens license requirements, this frequency allocation is not intended as an experimental band. All station equipment must be type approved by the FCC before the issuance of a station license. Any transmitter adjustments or maintenance which might effect its operating characteristics must be made by, or under the direct supervision of, the holder of a first- or second-class commercial license. The Commission must be notified of any major modifications which are made to the equipment during its use.

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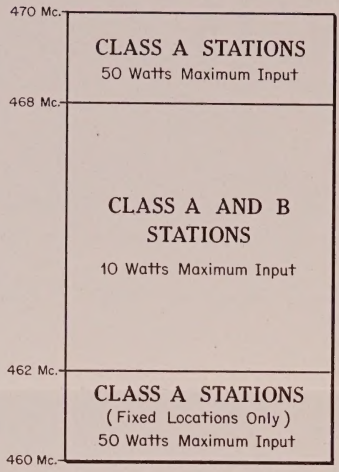
The regulations do, however, provide for the licensing of "composite" equipment which complies fully with the technical requirements of the Citizens Radio Service. The procedure for obtaining FCC approval for the construction and operation of such equipment is considerably more complicated than that outlined above for the case of commercially manufactured, type-approved equipment. Supplementary information, describing the complete design and testing of the composite equipment, must be submitted to demonstrate that it will comply with the rigorous engineering specifications. In some cases the FCC may require that the completed equipment be submitted to its laboratory for type-approval testing. The majority of war surplus radio equipment available in this frequency range, such as the BC-645 air-borne transponder beacon, has been found by the FCC to fall far short of the required technical standards of the service.

Technical Requirements

Two classes of licenses are issued which authorize operation of a station within the 460-470 Mc. citizens band. Fig. 2 shows the allocation of frequencies in the band according to class of license. The Class A license requires that the transmitter frequency be maintained constant to within plus or minus .02% of the intended operating frequency, and authorizes operation throughout the entire band. The Class B license permits frequency deviations up to plus or minus .4% of the mid-band frequency (465 Mc.) and all operation must be confined to this band. The maximum power input to the final tube or tubes in the transmitter for the three subdivisions of the band is also shown in Fig. 2.

The technical requirements of the Class A license effectively exclude all but carefully engineered, crystal controlled transmitters. No other known method of transmitter frequency control will dependably meet the .02% tolerance specified. Since low-drift quartz crystal oscillators are available only at relatively low frequencies, it is necessary to use a multi-stage transmitter to multiply the crystal frequency to the required citizens band frequency. The usual extent of such a crystal controlled transmitter is illustrated in block form in Fig. 3. It is common practice to accomplish the frequency multiplication in low power stages and use the output of these to drive a high-gain power amplifier at the output frequency.



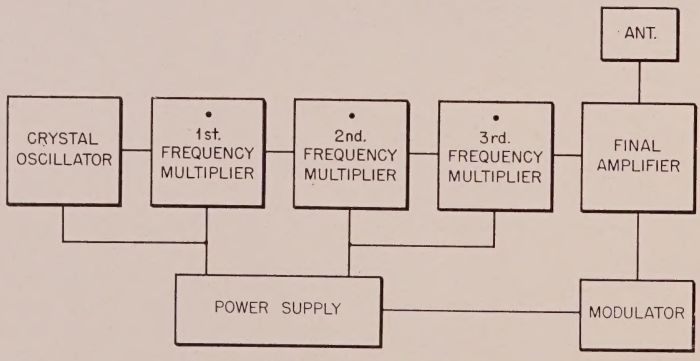
CITIZENS-BAND FREQUENCY ALLOCATIONS

FIG. 2

It is evident from Fig. 3 that the Class A requirements may be most easily met by stations operating at fixed locations, or in the more elaborate mobile installations. The inherent complexity of the high stability equipment and the accompanying heavy power drain make the hand-portable "walkie-talkie" type of operation improbable. High quality equipment is necessary for operation near the edges of the citizens band to avoid interference with important commercial services on adjacent frequencies. The recent allocation of UHF television channels starting at 475 Mc. makes the good conduct of stations in the Citizens Radio Service even more imperative. For this reason equipment meeting FCC approval must be as "fool-proof" as possible. Since it is intended for use by non-technical personnel, no control effecting the frequency of transmission should be accessible from the exterior of the equipment housing.

It is the Class B license which is intended to authorize the operation of greatly simplified portable communication equipment which might be carried on the person in the manner of the war-time "walkie-talkie" or "handie-talkie" sets. This mode of operation has the greatest appeal to the public and probably the greatest potential field of application. The technical requirements of this license may be met by relatively simple, lightweight sets of the "transceiver" type, in which the functions of transmitting and receiving are performed by the same tubes. Fig. 4 shows the minimum equipment requirement for such a station in block form. The transmitter is a self-excited oscillator, modulated by one or two audio amplifier stages driven by a high-output microphone. During receiving, the bias and plate voltage on the oscillator tube are switched to convert it to a superregenerative detector. The antenna remains coupled in the same manner, and the audio section is used to amplify the detected signal and drive a small speaker or headphones. The complete transition from "transmit" to "receive" is accomplished by a single switch or relay.

Although equipment of the transceiver type has been approved by the FCC for use in the citizens band, very careful engineering is required to comply with the Class B regulations. This difficulty is due to several inherent limitations in the performance of modulated, self-excited oscillators



CRYSTAL-CONTROLLED UHF TRANSMITTER

FIG. 3

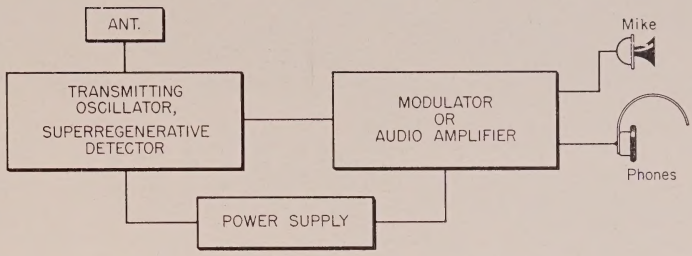
and transceivers in general. These limitations may be listed as follows:

(a) *Transmitter frequency instability.* The inherent frequency stability of most self-excited oscillators in the UHF range is very poor. The frequency is effected by changes in applied voltage, capacity changes caused by thermal expansion of vacuum tube elements, changes in ambient temperature and humidity, capacity variations due to proximity effects, antenna loading variations, and mechanical vibration. Voltage fluctuations due to plate modulation alone may cause frequency modulation amounting to several hundred kilocycles. The combined result of such effects is to make it exceedingly difficult to design an oscillator at 465 Mc. which will meet the prescribed tolerances in the hands of the public.

(b) *Receiver radiation.* The great simplicity of the transceiver results from the dual use of the tubes. However, when the transmitting tube is used as a superregenerative detector coupled directly to the antenna, a signal which is pulsed at the frequency of quenching is radiated. This signal is a potential source of interference to other citizens radio stations and adjacent services. Receiver radiation may be prevented by the addition of an r. f. stage between the antenna and the "superregen" detector, but the presence of this stage complicates the function of transmit-receive switching considerably.

(c) *Transmit-receive frequency difference.* Due to the change in operating voltage, there is a considerable difference between the frequency of transmission and reception in most transceivers. This discrepancy in frequency has the effect of causing two stations in communication to drift around the band unless the transmitter of each is retuned to a given frequency before every transmission.

Nevertheless, the transceiver presents a very inviting approach to the problem of simple and economical equipment for the Citizens Radio Service, and the solution of its limitations is a challenge to equipment designers.



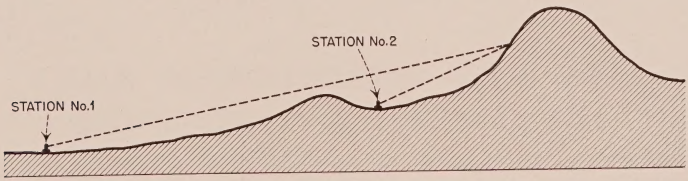
TRANSCEIVER BLOCK DIAGRAM
FIG. 4

Propagation Characteristics

Because the citizens band allocation is in the UHF portion of the radio spectrum, communication is usually limited to virtual line-of-sight distances. Stations using a few watts input, as is characteristic of stations of the "man-portable" kind, are able to communicate for distances ranging from a few blocks in very populous city areas, to several miles in residential districts having fairly flat terrain. Over truly optical paths, such as might exist between stations operating at elevated locations, appreciable distances may be spanned, even with very low power. The present record for amateur communication in the 420-450 Mc. band is 262 miles.

Waves at these frequencies are attenuated considerably by dense foliage. Antennas should, therefore, be above tree-top level wherever possible. Because of the portable applications of the service, vertical antenna polarization will be favored for its omnidirectional properties.

There are also very pronounced "shadowing" effects behind hills, tall buildings, and other large obstructions at these frequencies. In many cases, however, reception at such sites may be made possible by indirect path propagation of the type illustrated in Fig. 5. By this means, radio waves reflected by other large obstacles may reach the receiver by indirect routes.



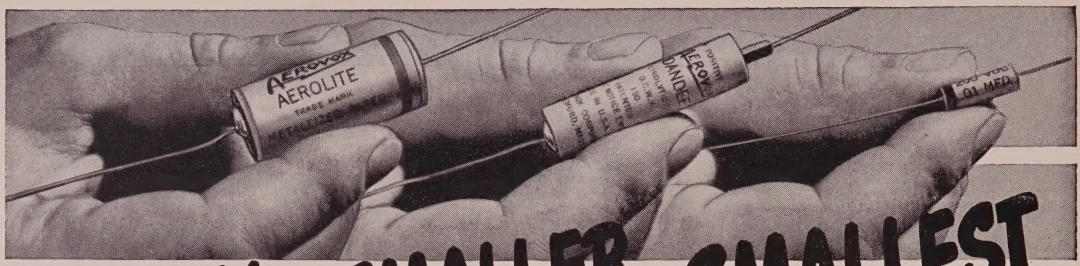
SHOWING UHF COMMUNICATION BY REFLECTED WAVES
FIG. 5

Citizens stations using the high-performance equipment specified for the Class A license, and the greater power permitted under these conditions, should enjoy considerably greater dependability of communication The use of very stable transmitters will permit relatively narrow-band, high-gain superhetrodyne receivers to be employed. The resulting improvement in receiver sensitivity should enable this type of station to communicate over distances several times greater than those covered by Class B stations. High-gain directional antennas of the kind shown in Fig. 6 of the August, 1949 AEROVOX RESEARCH WORKER may be employed by stations at fixed locations.

Commercial Aspects

The Citizens Radio Service represents a new field of endeavor for the manufacturer and radio service man. Since the licensing procedure for the service is based primarily upon the availability of commercially manufactured equipment, a large potential market exists for type-approved sets which can be economically produced. The high cost of satisfactory equipment for two-way radiotelephone communication is at present a major drawback in the expansion of this service.

In a similar manner, citizens radio provides a lucrative field for the service man who equips himself with a commercial radiotelephone license so that he may legally engage in installation and maintenance of citizens radio sets. As the service grows and gains in popularity it should be possible for an enterprising technician to build up a large clientele of citizens band licensees. Since the service man will have to assume responsibility for the proper functioning of the equipment under his care, it will be necessary for him to acquire some specialized test equipment, such as a precision UHF wavemeter, for this purpose.



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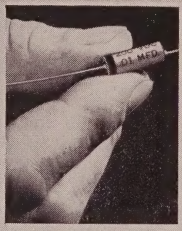

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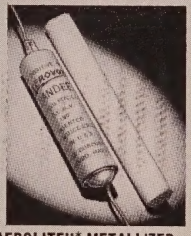

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